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The origin of radio haloes and non-thermal emission in clusters of galaxies

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abstract We study the origin of the non-thermal emission from the intracluster medium, including the excess hard X-ray emission and cluster-wide radio haloes, through fitting two representative models to the Coma cluster. If the synchrotron emitting relativistic electrons are accelerated *in situ* from the vast pool of thermal electrons, then a quasi-stationary solution of the kinetic equation with particle acceleration through turbulence at high energies ($> 200\,keV$) naturally produces a population of supra-thermal electrons responsible for the excess hard X-ray emission through bremsstrahlung. Inverse Compton scattering is negligible for X-ray energies in this case. The radio halo flux density constrains the magnetic field strength to a value close to that of equipartition $\sim 1\mu$G. Alternatively, if the relativistic electrons are injected from numerous localised 'external' sources then the hard X-rays are best explained by inverse Compton scattering from GeV electrons, and little of the hard X-radiation has a bremsstrahlung origin. In this case, the magnetic field strength is constrained to $\sim 0.1 - 0.2\,\mu$G. Both models assume that the non-thermal emissions are generated by a single electron spectrum, so that only two free parameters, well constrained by the observed hard X-ray and radio halo spectra, are needed in either case. Measurements of the cluster magnetic field will distinguish between the models.